

# Championing Open Architectures for ISHM

**PRESENTED TO:**

**CBM+ IPT  
OS-JTF**

**10 May 2006**

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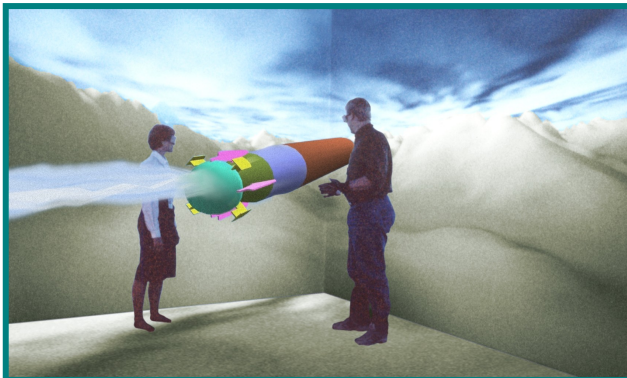
# University-Affiliated Research Center (UARC)



*Assist the DOD in identifying, prototyping and valuation of emerging technologies... and aid in their development and implementation.*



*Work as a trusted agent.*



***Mission summary:***

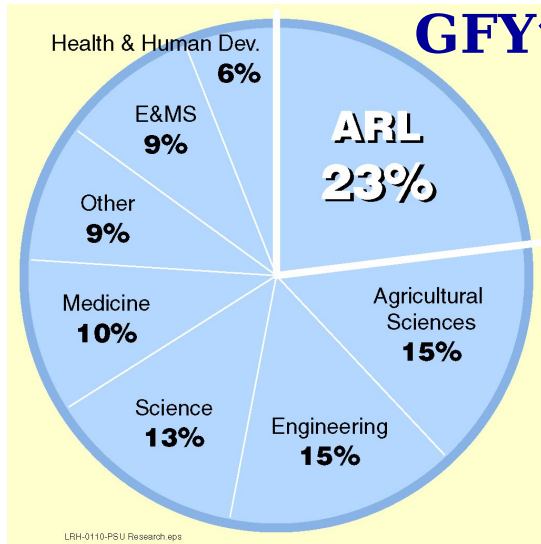
Research  
Technology Transfer  
Education



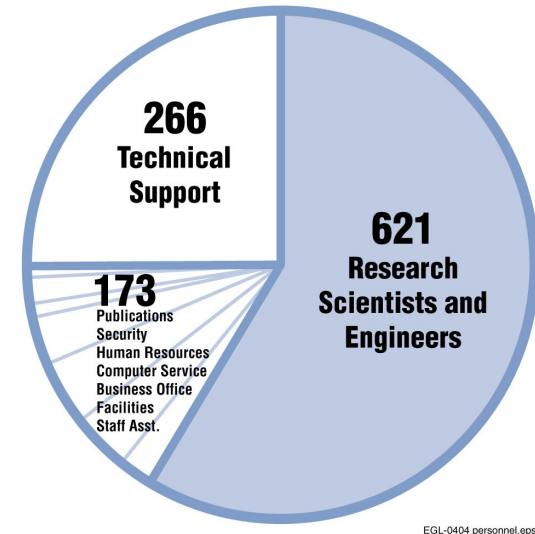
# Characteristics and Size

- ✓ Systems Engineering Orientation
- ✓ Basic Research thru Demonstration to Full-Scale Implementation
- ✓ Project Management of Cross-disciplinary, Multi-performer Teams

**\$154M**  
**GFY'04**

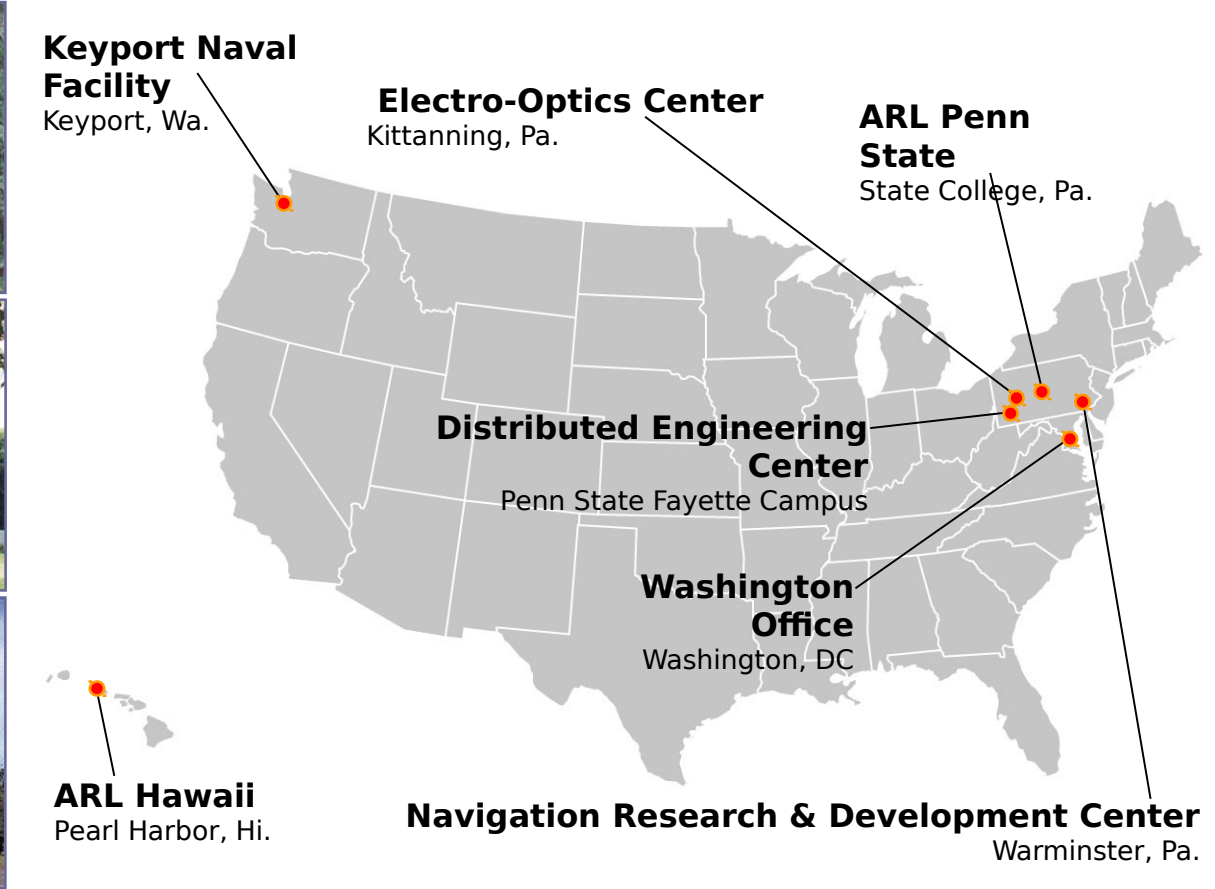


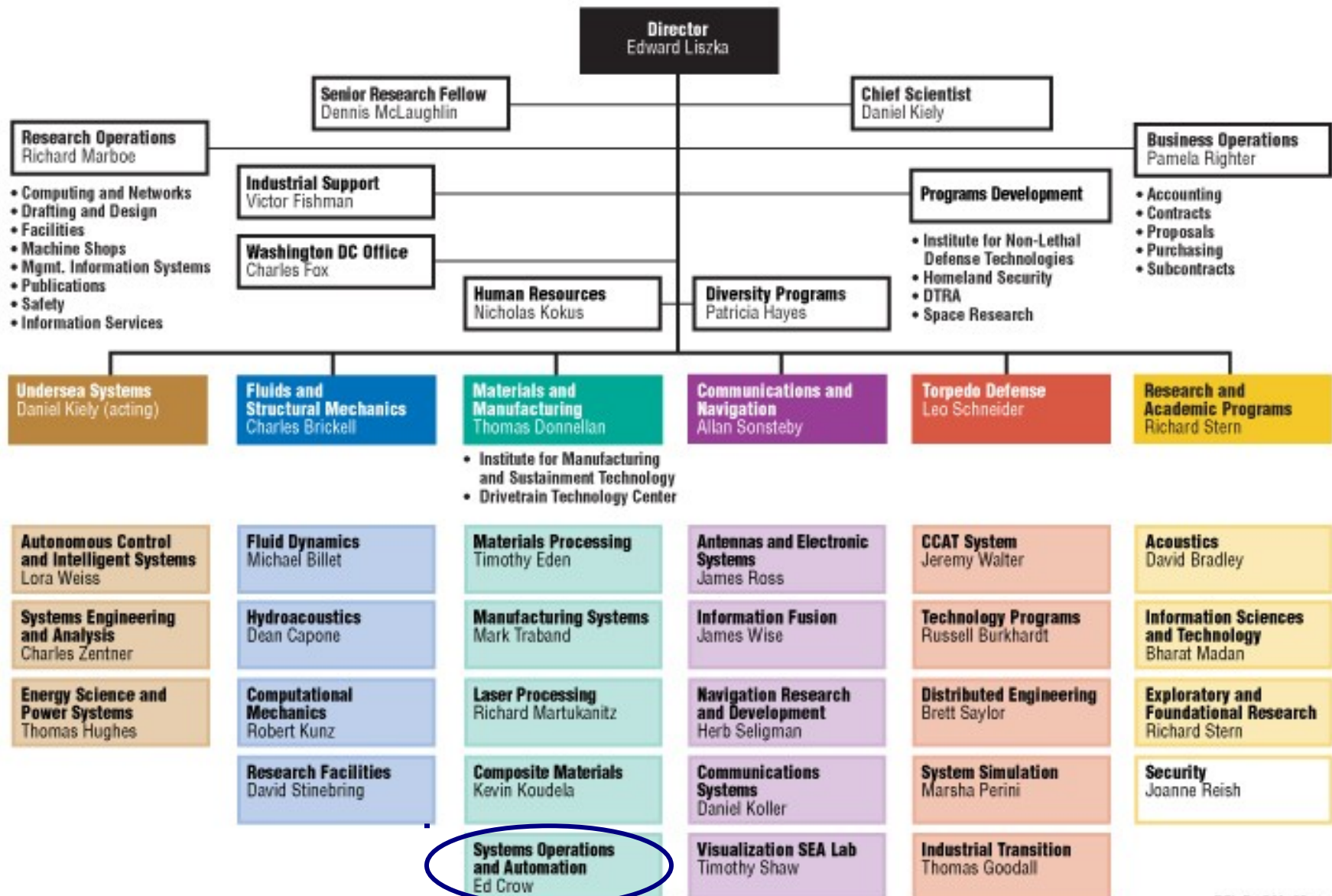
ARL Part of Penn State  
 Research FY 04-05  
 [\$492M]



ARL Full-Time Equivalent  
 Years of Effort

# ARL Locations





Demonstrate how to leverage asset health  
information throughout the enterprise

Develop new business processes incorporating asset health

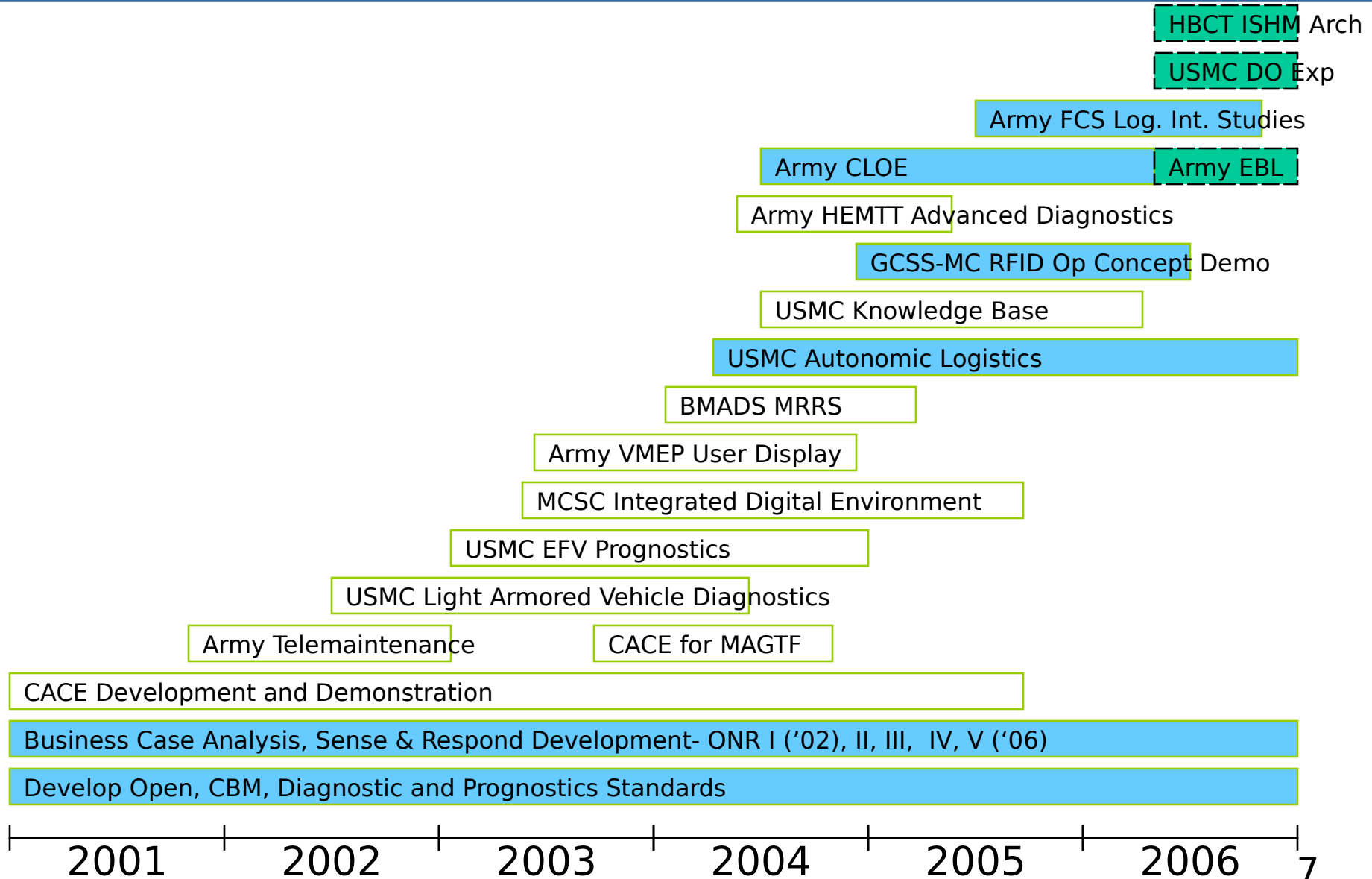
Develop new enterprise integration techniques

Transition results to defense, space and industry

Champion open standards



# Relevant Projects



1. What DOD programs are investing in ISHM and CBM?
2. What technologies are cutting across those programs?
3. Is there value to building common ISHM and CBM architectures?
4. What are the enablers for building a common ISHM and CBM architecture?
5. How do we get there?



# Condition Monitoring - Build on Open Standards

1. ISO-13374: Condition Monitoring and Diagnostics of Machines
  - Part 1 released
  - Part 2 in final draft, expect release in August 2006
  
2. MIMOSA OSA-CBM: Open System Architecture for Condition-Based Maintenance
  - Substantial enhancements in v3.1, May 2006
  - Harmonized with OSA-EAI in 2005
  
3. MIMOSA OSA-EAI: Open System Architecture for Enterprise Application Integration
  - Added to DISR 06.01 in March 2006 as a mandated standard
  - Data structures (CRIS Complete Object Model)
  - XML message schemas (Tech-XML)
  - Bulk data exchange (Tech-Compound Document Exchange (CDE))

# Time Line for Condition Monitoring Standards

## 2 year -OSA-CBM DUST Program (Funded by ONR)

- Newport News - Boeing
- Penn State /ARL Rockwell
- RLW - Caterpillar
- Oceana Sensors MIMOSA

## Developed Training Material and Examples - Penn State ARL, Boeing, Rockwell

## Developed OSA-EAI Tech-CDE - MIMSOA/ Penn State ARL

## ISO 13374-1 Standard Approved

## Harmonized the OSA-CBM and OSA-EAI Data Models - Boeing/MIMSOA

## Develop Joint OSA-CBM Demo

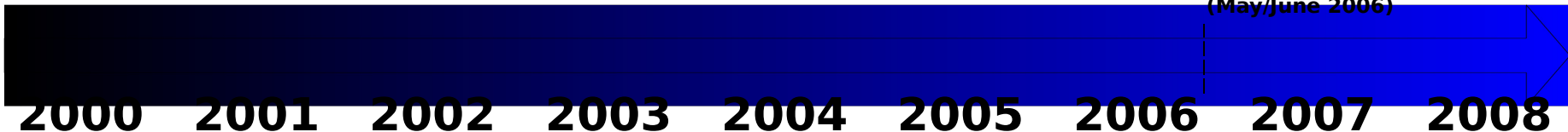
## Add OSA-CBM to DISR

## DOD includes OSA-CBM in Acq Req's

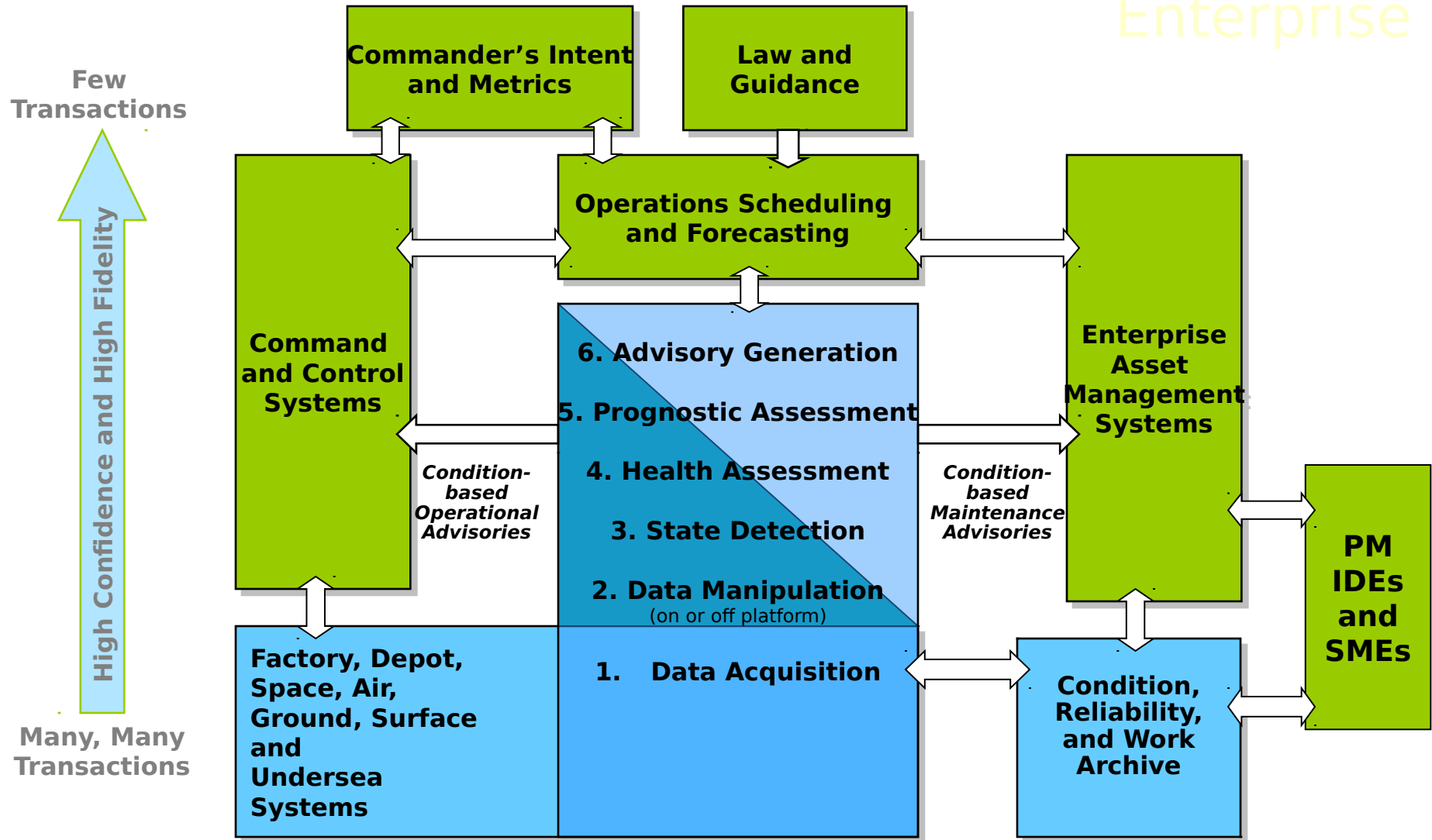


## Added OSA-EAI to DISR (March 2006)

## MIMOSA releases OSA-CBM Ver. 3.1 (May/June 2006)

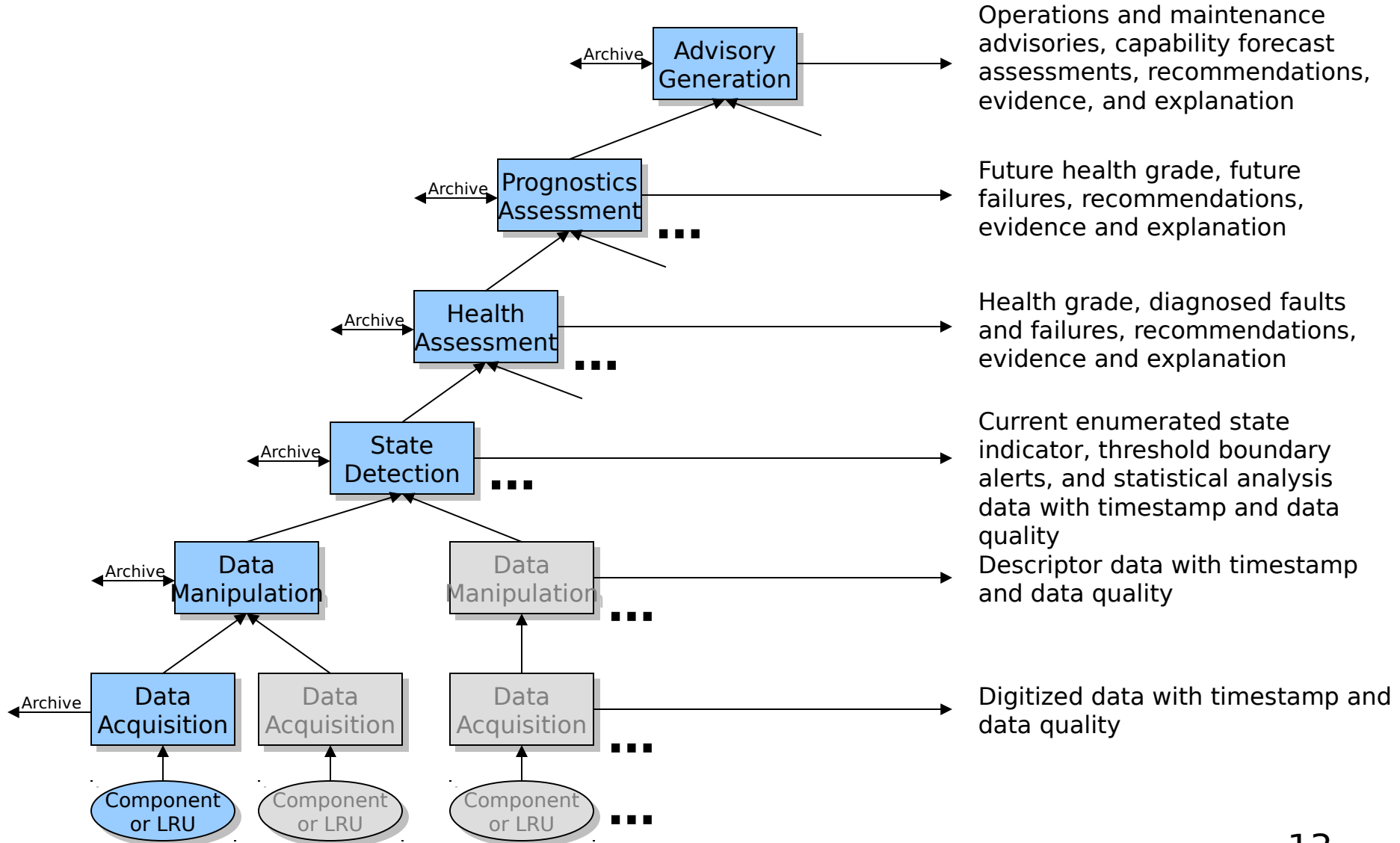


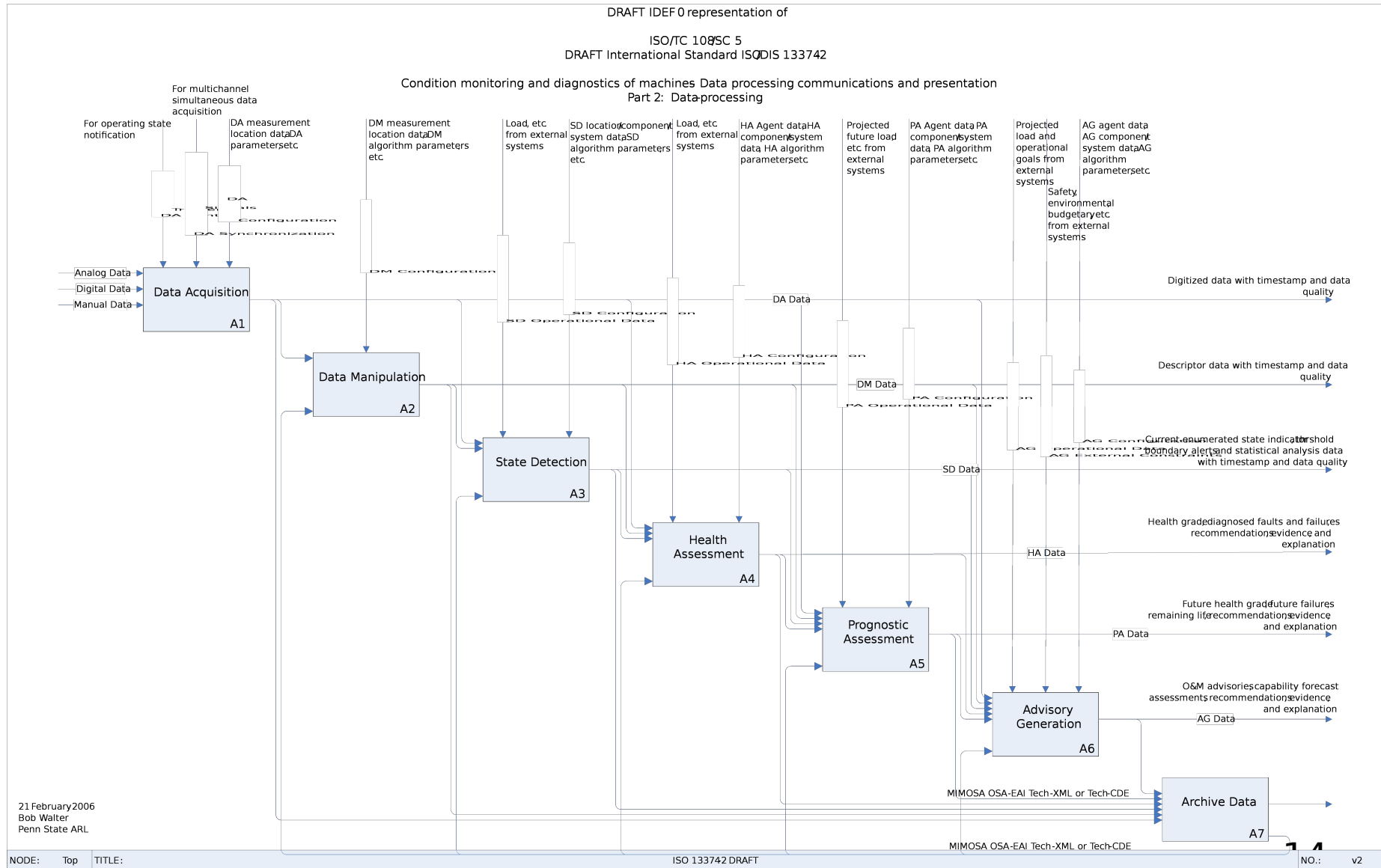
# Leveraging Asset Health Information throughout the Enterprise



- ISO-13374: Condition Monitoring and Diagnostics of Machines
  - Part 1 “General Guidelines” Released
  - Part 2 “Data Processing” Final Draft
  - Part 3 “Communication”
  - Part 4 “Presentation”
- “The various computer software systems written for condition monitoring and diagnostics (CM&D) of machines that are currently in use cannot easily exchange data or operate in a plug-and-play fashion without an extensive integration effort. This makes it difficult to integrate systems and provide a unified view of the condition of machinery to users. The intent of ISO-13374 Parts 1 through 4 is to provide the basic requirements for an open CM&D software architectures which will allow CM&D information to be processed, communicated and displayed by various software packages without platform-specific or hardware specific protocols.”
- Prepared by Technical Committee ISO/TC 108, Mechanical vibration and shock, Subcommittee SC 5, Condition monitoring and diagnostics of machines
- States that MIMOSA OSA-CBM is a compliant specification

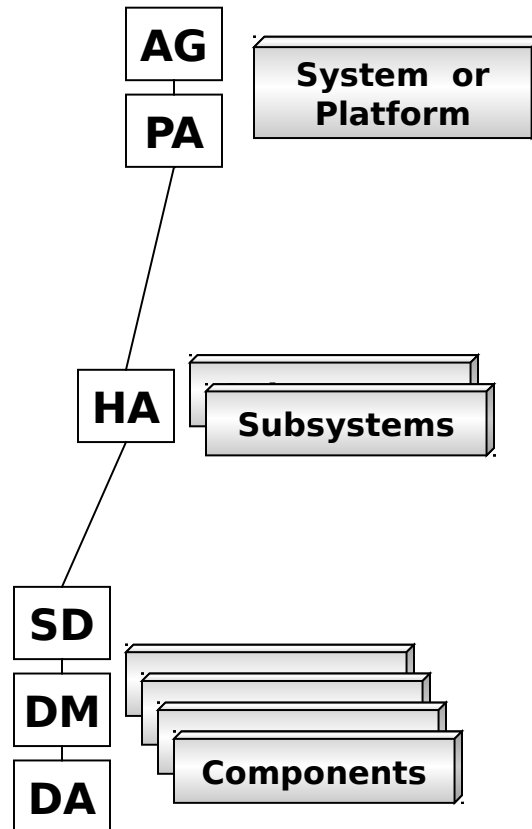
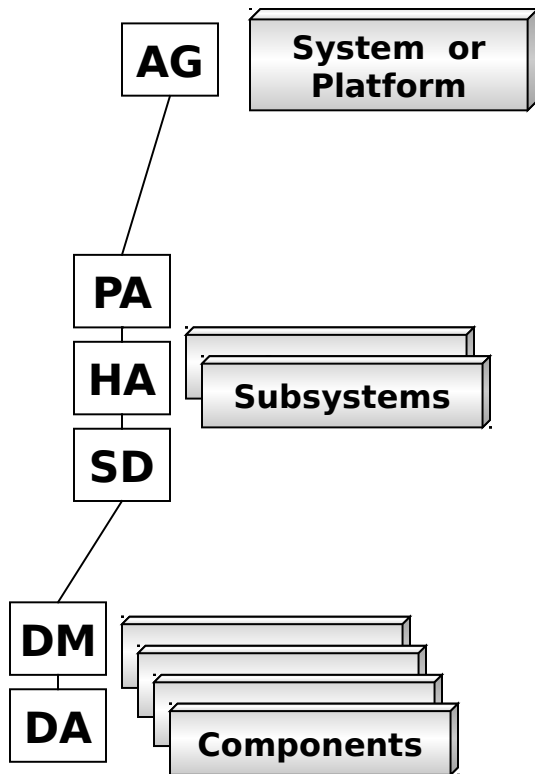




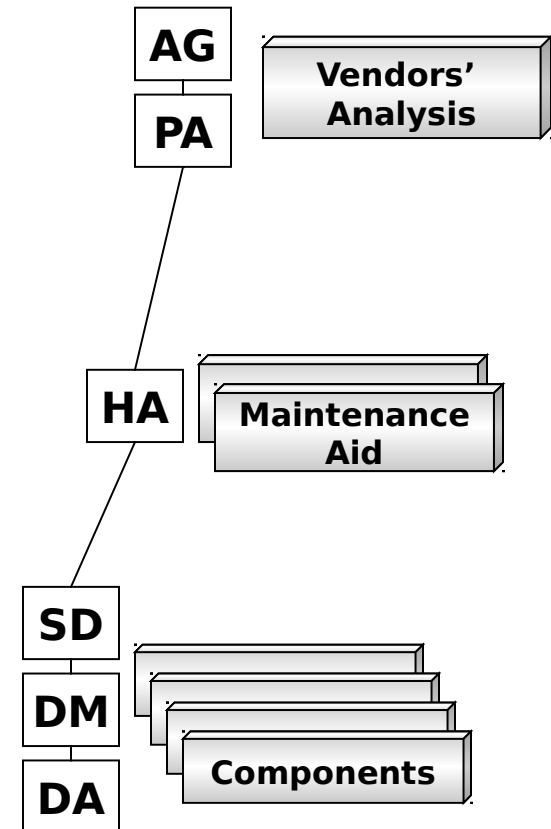


# Various ways to implement ISO-13374-2 in an ISHM Architecture

Or



Or



AG	Advisory Generation
PA	Prognostic Assessment
HA	Health Assessment
SD	State Detection
DM	Data Manipulation
DA	Data Acquisition

MIMOSA OSA-CBM does the following:

- Implements ISO-13374
- Specifically defines the functions for all six levels
  - Data
  - Configuration
  - Explanation
- Defines communications interfaces
- Does not define processing, functions and algorithms within the 6 level. Vendors do that and they can remain proprietary.

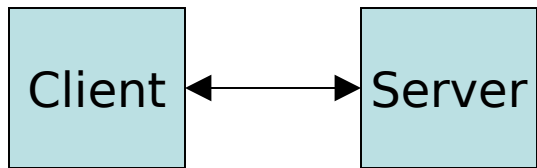
Status:

- Is harmonized with MIMOSA OSA-EAI
- Is managed by the MIMOSA standards body.
- Is available now to MIMOSA members
- Target is public release summer '06



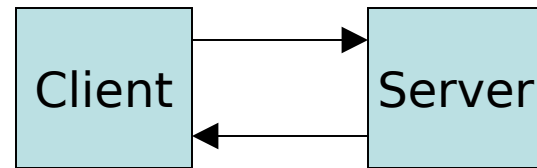
- OSA-CBM works in any programming language that supports remote procedure calls
- Examples:
  - CORBA (Common Object Request Broker Architecture)
  - DCOM (Distributed Component Object Model) / ActiveX
  - Microsoft .NET Framework
  - Web Services/SOAP (Simple Object Access Protocol)
  - JRMI (Java Remote Method Invocation)
  - REST (Representational State Transfer)

## 1. Synchronous



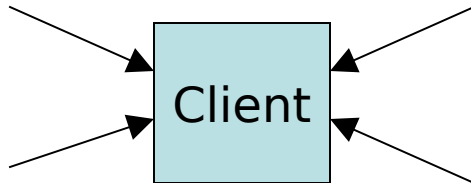
Data returned through function call

## 2. Asynchronous



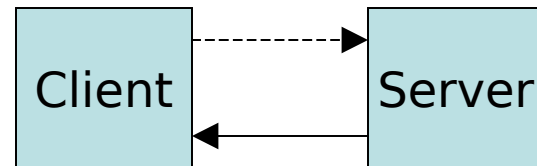
Data returned in separate return call

## 3. Service



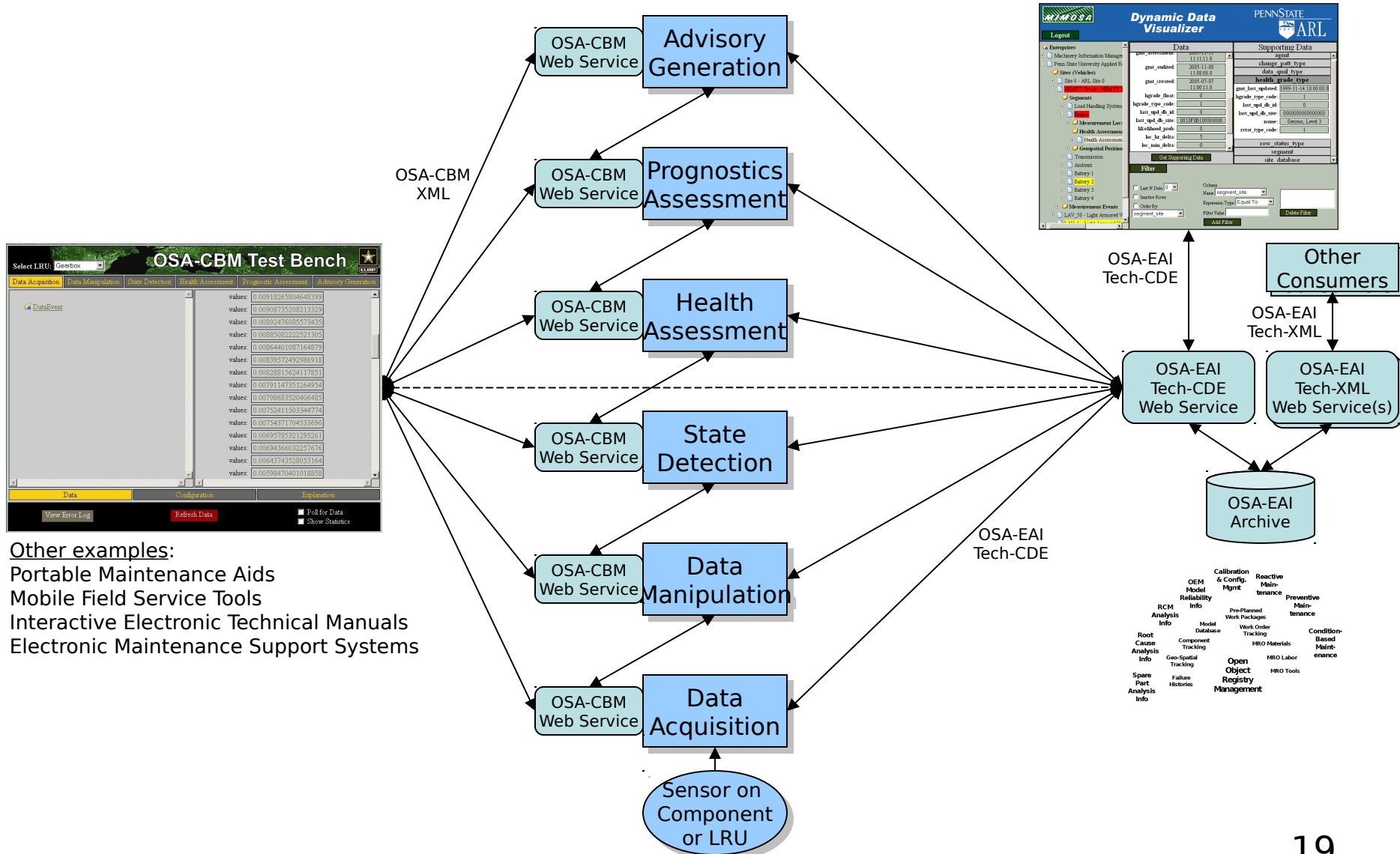
Client only accepts data (for example, a database for archiving data)

## 4. Subscription

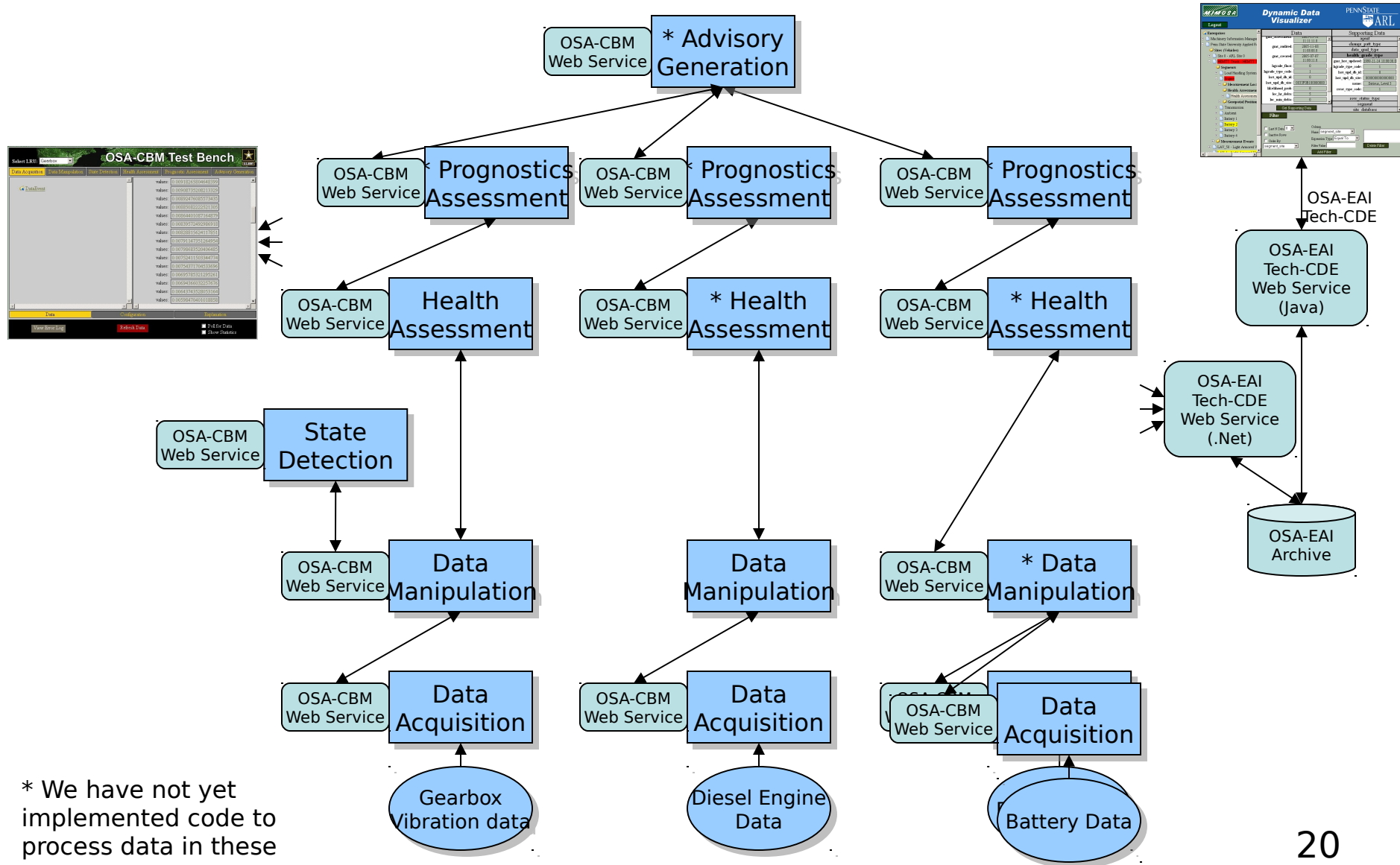


Client subscribes to data, which Server sends regularly or on alert

# Implementing MIMOSA Standards for Integrated System Health Monitoring (ISHM) in a Services Oriented Architecture (SOA)



# OSA-CBM Demonstration Configuration







# Net Centric Design Tenets

## I. Data

- A. Implement DoD Net-Centric Data Strategy
- B. Make data visible
- C. Make data accessible
- D. Make data understandable
- E. Make data trustable
- F. Make data interoperable
- G. Provide Data Management
- H. Be Responsive to User Needs

## II. Services

- A. Service-Oriented Architecture
- B. Open Architecture
- C. Scalability
- D. Availability
- E. Accommodate heterogeneity
- F. Decentralized operations and management
- G. Enterprise Service Management






## III. Information Assurance/Security

- A. DoD Net-Centric IA Strategy
- B. Net Centric IA Posture and Continuity of Operations
- C. Identify Management, Authentication and Privileges
- D. Mediate Security Assertions
- E. Cross Security Domains Exchange
- F. Encryption and HAIPE
- G. Employment of Wireless Technologies

## IV. Transport


- A. IPv6
- B. Packet Switched Infrastructure
- C. Layering, Modularity
- D. Transport Goal
- E. Network Connectivity
- F. The Concurrent Transport of information Flows
- G. Differentiated Management of Quality-of-Service
- H. Inter-Network Connectivity
- I. Technical Architecture
- J. RF Acquisition
- K. Joint Net-Centric Capabilities
- L. Operations and Management of Transport and Services

# Net Centric Attributes

Title	Description	Metric	Source
Internet Protocol (IP)	Data packets routed across network, not switched via dedicated circuits	<b>IP as the Convergence Layer</b> Net-Centric Operations and Warfare Reference Model (NCOW RM), Technical View compliant with DISR	NCOW RM, GIG Arch v2, IPv6 Memos (9 Jun 03 and 29 Sep 03),
Secure and available communications	Encrypted initially for core network; goal is edge-to-edge encryption and hardened against denial of service	<b>Black Transport Layer</b> Transformational Communications Architecture (TCA) compliance; Technical View compliant with DISR	TCA; IA Component of Assured GIG Architecture;
Only handle information once (OHIO)	Data posted by authoritative sources and visible, available, usable to accelerate decision making	<b>Reuse of existing data repositories</b> 	Community of interest policy (TBD)
Post in parallel	Business process owners make their data available on the net as soon as it is created	<b>Data tagged and posted before process</b> 	NCOW RM, DoD Net-Centric Data Strategy (May 9, '03)
Smart pull (vice smart push)	Applications encourage discovery; users can pull data directly from the net or use value-added discovery services	<b>Data stored in public space and advertised (tagged) for discovery</b> 	NCOW RM; DoD Net-Centric Data Strategy (May 9, '03);
Data centric	Data separate from applications; apps talk to each other by posting data	<b>Metadata registered in DoD Metadata Registry</b> 	NCOW RM; DoD Net-Centric Data Strategy (9 May 03);
Application diversity	Users can pull multiple apps to access same data or choose same app (e.g., for collaboration)	<b>Apps posted to net and tagged for discovery</b> 	NCOW RM;
Assured Sharing	Trusted accessibility to net resources (data, services, apps, people, collaborative environment, etc.)	<b>Access assured for authorized users; denied for unauthorized users</b>	Security/IA policy Nov 21, '03); IA Component of Assured GIG Architecture;
Quality of service	Data timeliness, accuracy, completeness, integrity, and ease of use	<b>Net-ready key performance parameter</b>	Service level agreements (TBD);

Select LRU: Gearbox

OSA-CBM Test Bench



Data Acquisition

Data Manipulation

State Detection

Health Assessment

Prognostic Assessment

Advisory Generation

Configuration

importModuleSet

moduleRefs

modId

importRefs

moduleId

algorithms

algorithms

algorithms

algorithms

algorithms

description: computes root-mean-square

name: RMS

processDesc: -

URIprocessDesc: -

userTag: -

verNum: 1

Data

Configuration

Explanation


View Error Log

Refresh Data

Show Statistics

Select LRU: Gearbox

OSA-CBM Test Bench



Data Acquisition

Data Manipulation

State Detection

Health Assessment

Prognostic Assessment

Advisory Generation

[-] DataEventSet

[+] site

[+] time

[+] DMReal

[+] DMReal

[+] DMReal

[+] DMReal

[+] DMReal

[+] DMReal

[+] DMReal

[+] DMReal

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[+] DMReal

alertStatus: false

confid: 0.95

id: 14

dataStatus: OK

value: 3.05808423101916

Data

Configuration

Explanation

View Error Log


Refresh Data

☐ Show Statistics



Select LRU: Gearbox

## OSA-CBM Test Bench



Data Acquisition

Data Manipulation

State Detection

Health Assessment

Prognostic Assessment

Advisory Generation

```

<DataEventSet>
<alertStatus>false</alertStatus>
<id>1</id>
<site>
<category>SITE_PLAT</category>
<siteId>0033F0B100000003</siteId>
<regId></regId>
<userTag></userTag>
</site>
<time>
<time>5/9/2006 10:31:47 AM</time>
</time>
<DMReal>
<alertStatus>false</alertStatus>
<confid>1</confid>
<id>0</id>
<dataStatus>OK</dataStatus>
<value>23.2184810638428</value>
</DMReal>
<DMReal>

```

Message Length: 2549 bytes

Latency: 4866 milliseconds

Data

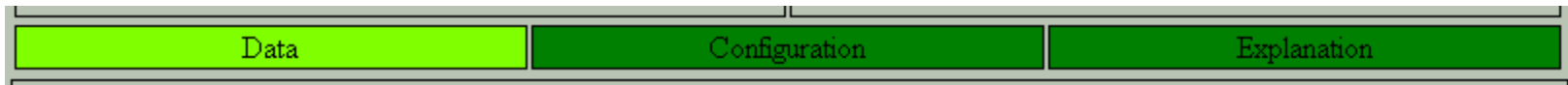
Configuration

Explanation

View Error Log

Refresh Data

☒ Show Statistics



**Data** is 'DataEvent' class information that is sent to the user from an OSA-CBM layer. (A 'DataEvent' contains the data for a **data generation event**.)

The 'DataEvent' class has a child hierarchy below it associated with the layers in the OSA-CBM architecture (i.e. DADataEvent, DMDDataEvent, etc...). These classes have child classes below them that describe particular data types (e.g. vectors, waveforms, enumerations, health information, etc...) that can be provided to the user.

Data	Configuration	Explanation
------	---------------	-------------

**Configuration** information contains four principal child classes:

- ‘InportModuleSet’ provides information about where a layer gets data from.
- ‘Algorithm’ describes the process used to generate a ‘DataEvent’.
- ‘OutPortSet’ lists every ‘OutPort’. An “out port” is a data channel and the ‘OutPort’ class gives specific configuration data for that channel.
- ‘SupportingData’ gives additional information about MIMOSA MIMKey or primary key references used elsewhere in the architecture.



**Explanation** information consists of four possible forms:

- The first is simply the data used for a calculation.
- The second is a handle / timestamp type of reference to the data used. The main example is data stored in a database.
- Third, is a set of direct pointers to the modules supplying the data.
- Fourth, is a “stringified” form of a pointer that will allow the user to construct a pointer to the module.

- MIMOSA OSA-EAI is compliant with ISO-13374 parts 1 and 2
- Facilitates the integration of asset management and CM&D information throughout multi-site enterprises
- All OSA-EAI products are built from a common object model representing the CM&D domain

# MIMOSA OSA-EAI Overview

## Machinery Information Management Open Standards Alliance (MIMOSA)

MIMOSA database schemas and XML message schemas are all derived from a common object model CCOM.



### MIMOSA Technology Types

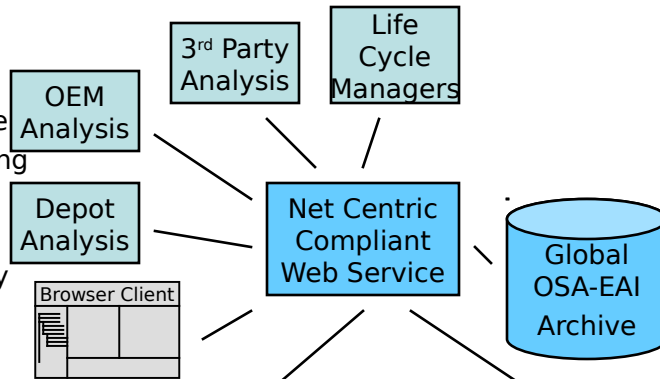
REG (Physical Asset Register Management)  
 WORK (O&M Agent Work Management)  
 DIAG (Diagnostics / Prognostics / Health Assessment)  
 TREND (Operational Scalar Data & Alarms)  
 DYN (Dynamic Vibration/Sound Data & Alarms)  
 SAMPLE (Oil/Fluid/Gas/Solid Test Data & Alarms)  
 BLOB (Binary Data/Thermography Data & Alarms)  
 REL (RCM/FMECA/Model Reliability Information)  
 TRACK (Physical Asset GeoSpatial Tracking Info.)  
 V3.2 ALGORITHM (Algorithm Management Information)  
 V3.2 AGENT (Intelligent Agent Management)



# Making the ISHM Archive Information Accessible to All Consumers using OSA-EAI Tech-CDE v3.1

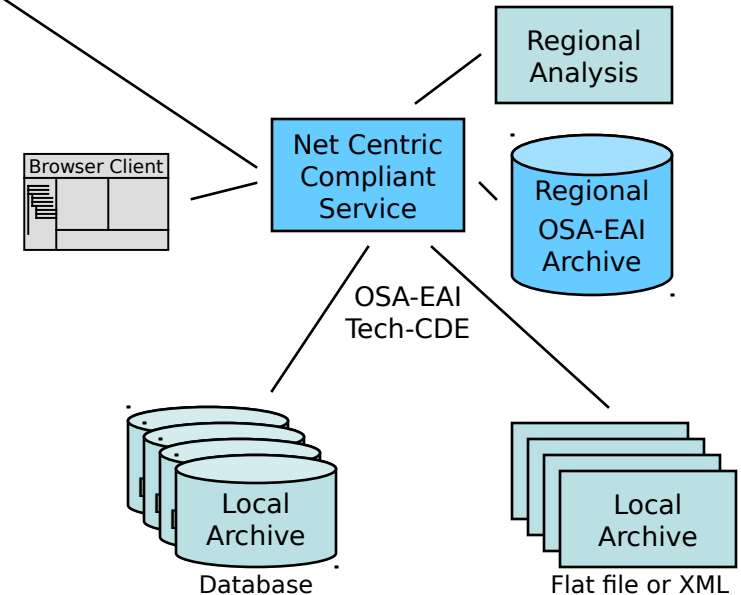
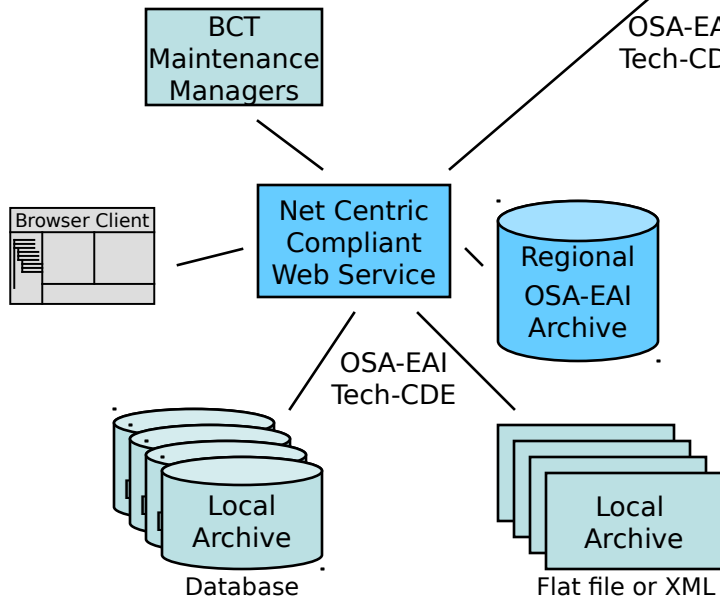
## Net Centric Attributes


Only handle information once  
Tag and post before processing  
Store publicly and advertise  
Register metadata  
Tag applications for discovery




## MIMOSA OSA-EAI Technology Types [Tech-]

REG (Physical Asset Register Management)  
WORK (O&M Agent Work Management)  
DIAG (Diagnostics / Prognostics / Health Assessment)  
TREND (Operational Scalar Data & Alarms)  
DYN (Dynamic Vibration/Sound Data & Alarms)  
SAMPLE (Oil/Fluid/Gas/Solid Test Data & Alarms)  
BLOB (Binary Data/Thermography Data & Alarms)  
REL (RCM/FMECA/Model Reliability Information)  
TRACK (Physical Asset GeoSpatial Tracking Info.)  
*ALGORITHM (Algorithm Management Information)*  
*AGENT (Intelligent Agent Management Information)*  
*FORECAST (Capability Forecasting & Projections)*





## Dynamic Data Visualizer



**Logout**

**Enterprises**

- + Machinery Information Manager
- Penn State University Applied R...
- Sites (Vehicles)**
  - + Site 0 - ARL Site 0
  - **HEMTT Truck - HEMTT 2**
  - Segments**
    - + Load Handling System
    - **Engine**
    - + Measurement Loca...
    - Health Assessment**
      - + Health Assessment
      - + **Geospatial Position**
        - + Transmission
        - + Ambient
        - + Battery 1
        - + **Battery 2**
        - + Battery 3
        - + Battery 4
    - + **Measurement Events**
      - + LAV\_50 - Light Armored V...
      - + T-140 - Light Armored V...

Data		Supporting Data	
gmt_assessment:	2005-11-11 11:11:11.0	agent	
gmt_audited:	2005-11-08 11:08:08.0	change patt type	
gmt_created:	2005-07-07 11:00:11.0	data qual type	
		health grade type	
hgrade_float:	0	gmt_last_updated:	1999-11-14 18:00:00.0
hgrade_type_code:	1	hgrade_type_code:	1
last_upd_db_id:	0	last_upd_db_id:	0
last_upd_db_site:	0033F0B100000000	last_upd_db_site:	000000000000000000
likelihood_prob:	0	name:	Serious, Level 3
loc_hr_delta:	5	rstat_type_code:	1
loc_min_delta:	0		
Get Supporting Data		row status type	
		segment	
		site database	

**Filter**

☐ Last N Data 0
☐ Inactive Rows
 ☐ Order By
 

segment\_site

Column Name: 

segment\_site

 Expression Type: 

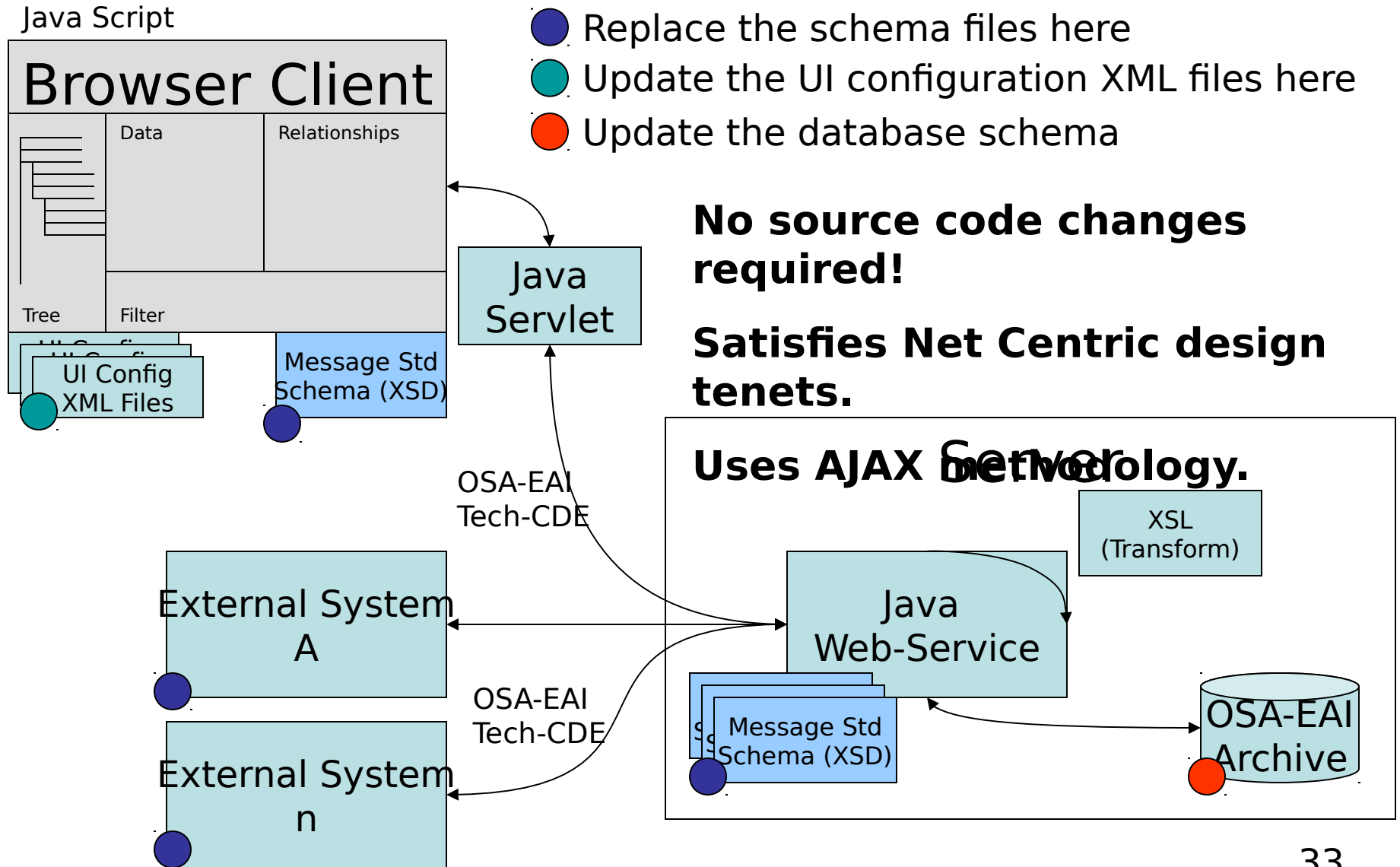
Equal To

Filter Value:

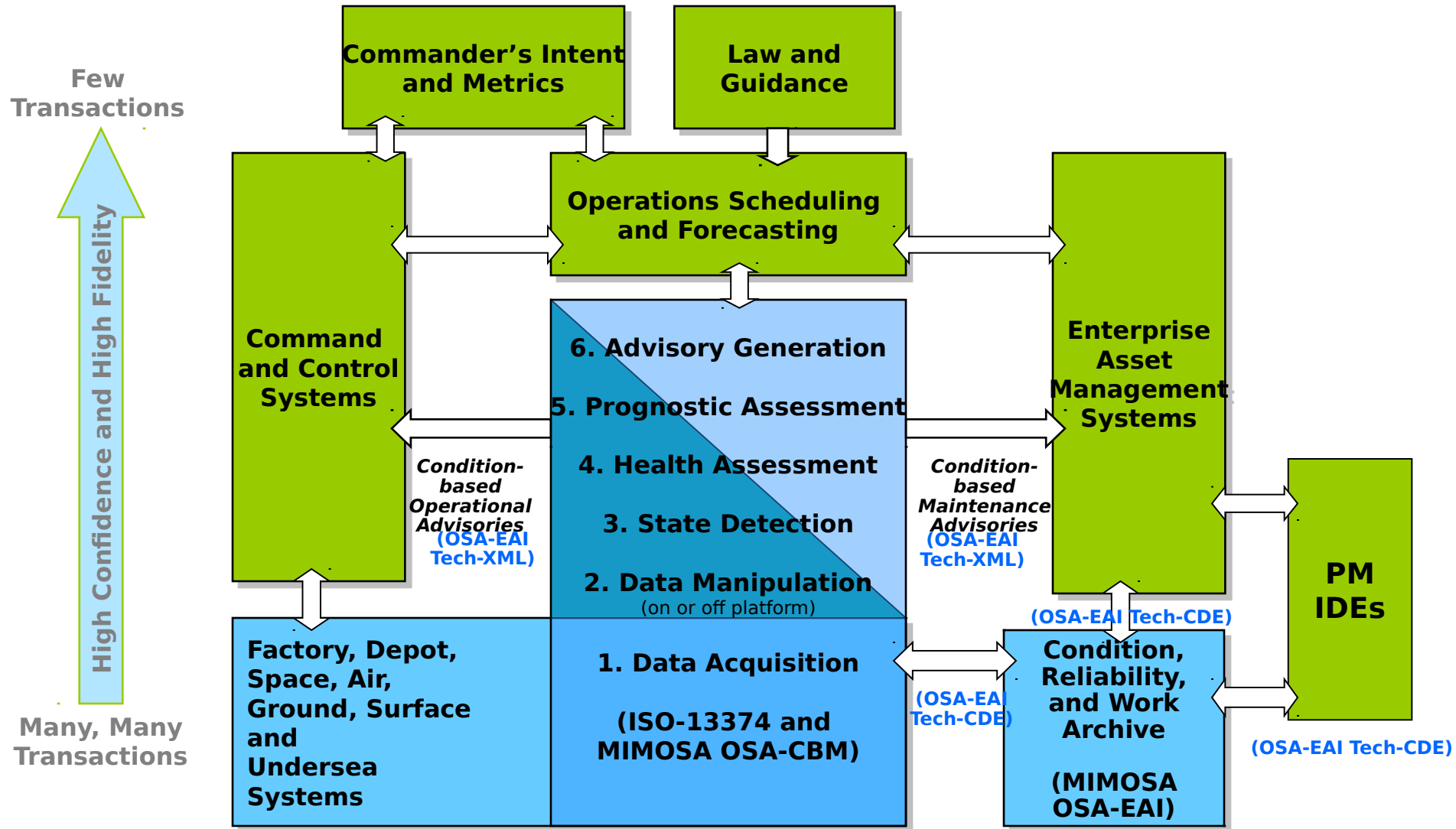
**Delete Filter**

Add Filter

# Messaging Standard Updates are Much Simpler to Implement!

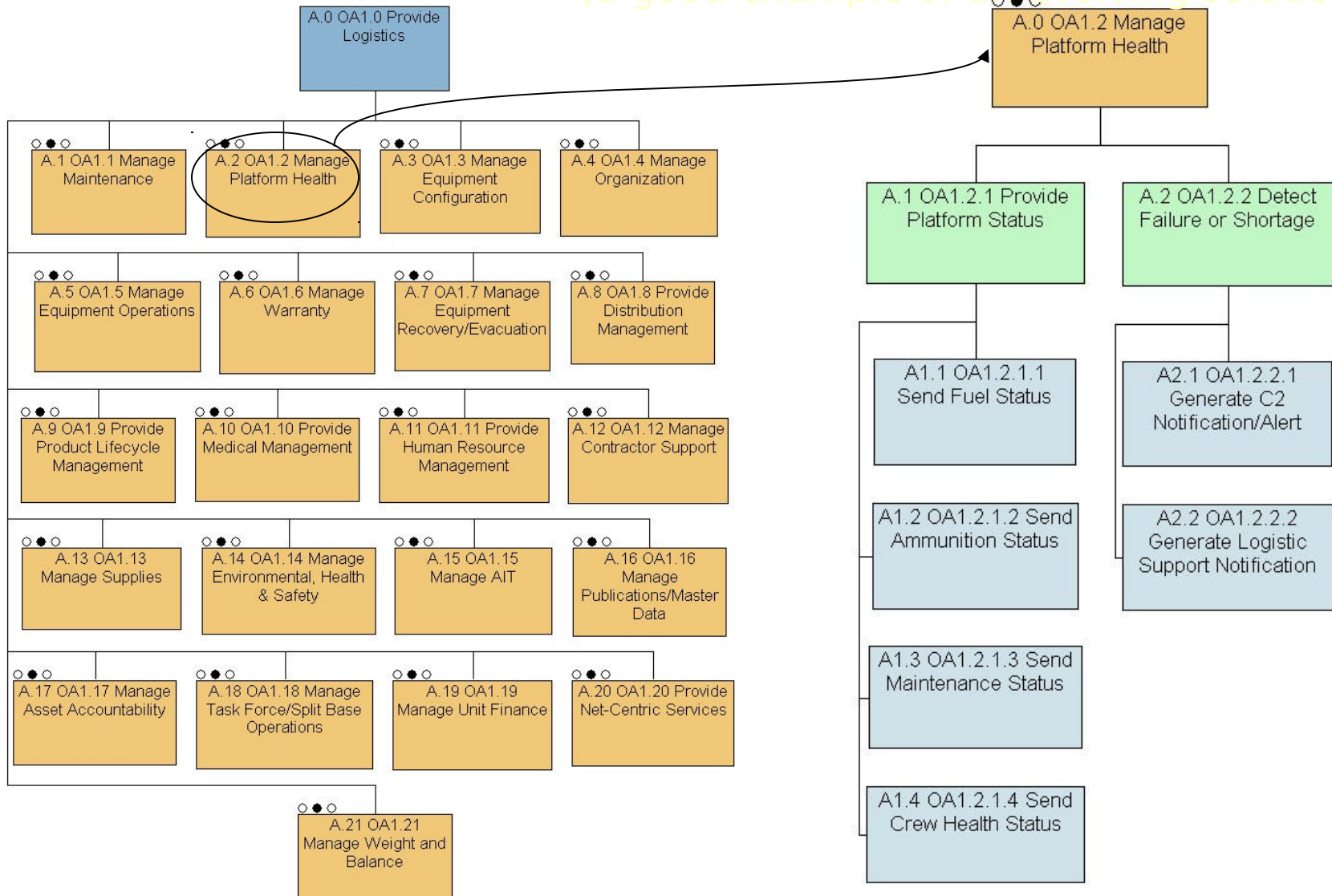


# Leveraging asset health information throughout the enterprise using open standards.



# Army Integrated Logistics Architecture (AILA) V1.1 OV-5

(a good example of an evolving solution)

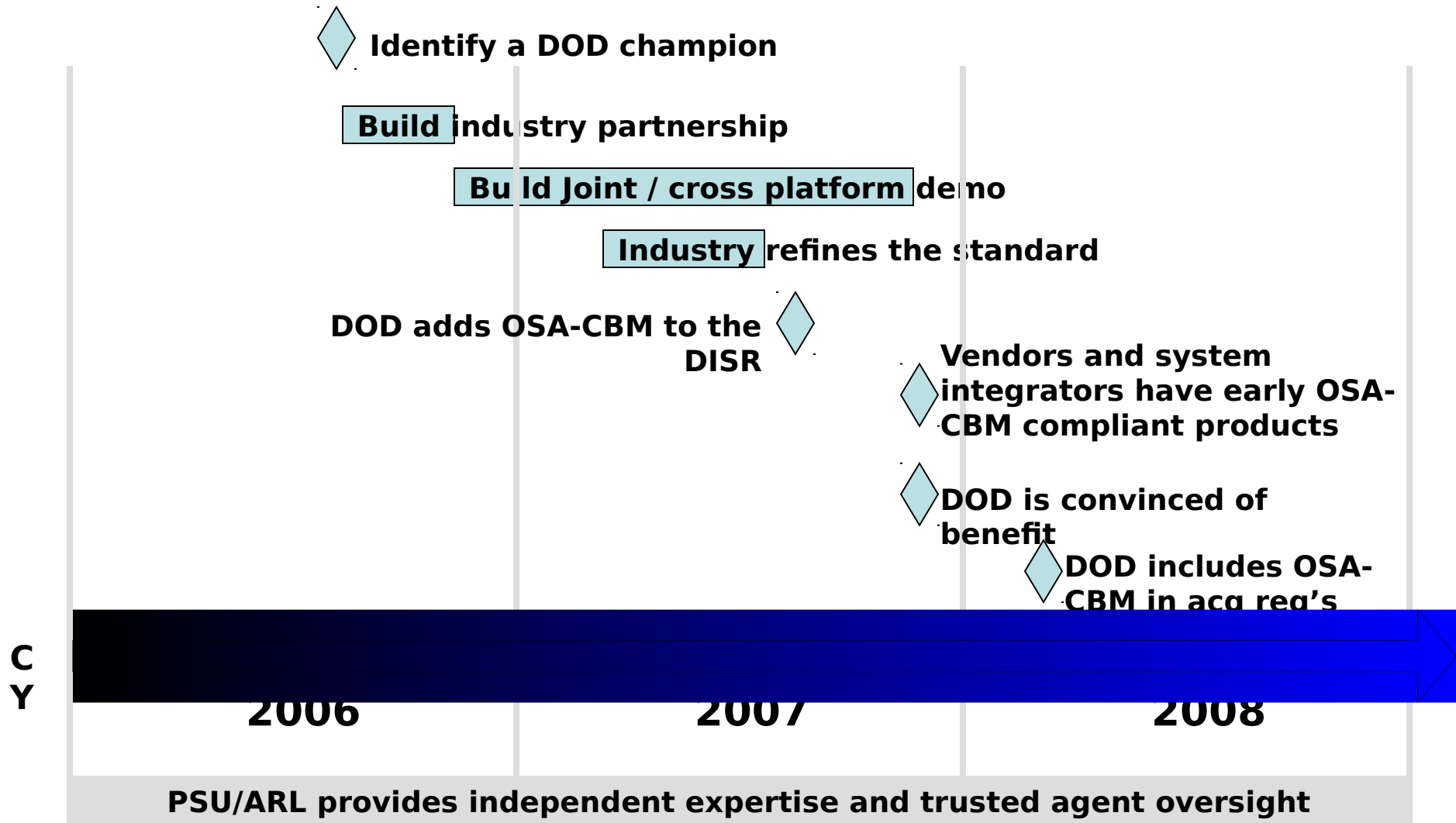


## 5 Question Quiz (revisited)

1. What DOD programs are investing in ISHM and CBM?
2. What technologies are cutting across those programs?
3. Is there value to building common ISHM and CBM architectures?
4. What are the enablers for building a common ISHM and CBM architecture?
5. How do we get there?



# Conceptual OSA-CBM Program



# The Applied Research Laboratory

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